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AN ASSESSMENT OF PESTICIDE RESEARCH PROJECTS

Funded by the Ministry of the Environment through the Ontario Pesticides Advisory Committee

1980 - 1981

Ontario

The Ontario Pesticides
Advisory Committee

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FUNDED BY

THE MINISTRY OF THE ENVIRONMENT

THROUGH

THE ONTARIO PESTICIDES ADVISORY COMMITTEE

1980-1981

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TABLE OF CONTENTS

RESEARCH PROJECTS FUNDED THROUGH THE ONTARIO PESTICIDES ADVISORY COMMITTEE

1980-81

I. SUMMARY

1) In 1980-81, the Ontario Pesticides Advisory Committee continued a program, begun in 1973, of funding research on pesticides. The objectives of the program are:

   a) To find alternative pesticides for those deemed environmentally hazardous and thus restricted in use.

   b) To determine potential environmental hazards with pesticides currently in use.

   c) To reduce pesticide input into the environment.

2) Fifty-four research proposals totalling $1,366,314.00 were received.

3) Twenty-one research proposals were funded with a total value of $199,270.00. Awards averaged $9,489.00 and ranged from $1,000.00 to $50,000.00.

4) Four grants totalling $72,500.00 were awarded for studies on development of alternative pesticides for pest control.

5) Seven grants totalling $45,500.00 were allocated to studies on the behaviour and fate of pesticides in the environment and on potential environmental hazards to non-target organisms.

6) Ten grants totalling $81,270.00 were allocated for studies aimed at reducing pesticide input into the environment, while still achieving effective pest control.

7) The Pesticides Advisory Committee is very satisfied with the research progress made in 1980-81. It recognizes that with the limited funds available the program of grants can be expected to act only as a catalyst in stimulating research in the broad areas indicated in the Committee's guidelines for which there is still an urgent requirement.

II. RECOMMENDATIONS

The Pesticides Advisory Committee recommends that:

1) The Ministry of the Environment continue to support research programs directed toward development of pest control programs which will not pose any serious environmental hazard.

2) The Pesticides Advisory Committee continue to supervise this program following guidelines which have been developed.

III. REVIEW OF THE RESEARCH PROGRAM

The Ministry of the Environment first allocated funds to the Ontario Pesticides Advisory Committee to sponsor pesticide-related research in 1973. Results have been summarized in Annual Reports (OPAC 1974-1980, incl.). A five year assessment of progress was included in the 1978 report. Results obtained have encouraged the committee to recommend that the research program be continued under its supervision and the committee is gratified that this recommendation has been accepted. The OPAC research budget in 1980-81 was $200,000.

Terms of reference developed by OPAC to govern the awarding of research grants are based on three objectives, i.e. the need to find suitable replacements for pesticides deemed hazardous and restricted for use in Ontario; the need to determine if pesticides in use pose any serious environmental hazard; and the need to develop more effective approaches to pest control leading to a reduction of pesticide input into the environment. The "Application for Research Support" (Appendix I) invited proposals in six general areas relating to these three objectives. Invitations for applications for research support were widely distributed in January, 1980 to personnel in Ontario universities, industry and government (copies of the mailing list are available on request), with deadlines for applications being February 28, 1980.

Fifty-four research proposals totalling $1,366,314. were received. Most (47) were from universities/colleges (Carleton, Guelph, Laurentian, McMaster, Ottawa, Queen's, Sault College of Applied Technology, Toronto, Waterloo, Western, York). The remaining applications were submitted by industry or other organizations. (A list of titles of research proposals submitted for consideration by OPAC is available on request). Applications were considered first by the research subcommittee (J. R. Carrow, G. S. Cooper, P. D. Foley, C. D. Fowle, R. Frank, F. L. McEwen, G. R. Stephenson, D. W. Wilson, and C. R. Harris (Chairman)), and then by the Advisory Committee. Twenty-one proposals were accepted, valued at $199,270. Awards averaged $9,489 (range $1,000 to $50,000). Most of the grants were awarded to individuals at universities. Disbursement of research funds by organization is summarized below.

Organization	Number of research grants awarded	Total research funds ($)
University of Guelph	11	120,270
University of Western Ontario	4	39,000
University of Waterloo	2	11,500
Sault College of Applied Technology	1	13,000
York University	1	3,000
Other	2	12,500
	21	199,270

Direction and progress of the research program were monitored by the Advisory Committee in several ways. Initially, some applicants were asked to modify their proposals to better meet the research guidelines. Informal contacts between the research subcommittee and some grant recipients were established. In January, 1981, OPAC sponsored a two-day research seminar at which recipients of grants discussed their research results. This meeting was attended by Advisory Committee members and >80 people interested in pesticide-related research. Each recipient of a grant was asked to provide OPAC with a summary of results (Appendix III). Published research reports relating to research sponsored by the Pesticides Advisory Committee are listed in Appendix IV.

Progress made in 1980-81 relative to the objectives of the research program may be summarized as follows:

Objective 1: To find alternative pesticides for those deemed environmentally hazardous and thus restricted in use.

During the past 10 years environmental concerns have resulted in restrictions in the use of a number of important pesticides in Ontario. In some cases alternative chemicals or approaches to control were available. However, in other instances no adequate alternative control measures were feasible; or the alternative approaches adopted did not prove satisfactory; or the substitute chemicals used presented their own special hazard, e.g. the high mammalian toxicity of some organophosphorus (OP) insecticides. In these situations, OPAC has funded research aimed at developing satisfactory methods of pest control. Four grants were awarded under this objective in 1980-81 totalling $72,500.

Biting flies are "nuisance" pests and disease transmitters. In 1980-81 continued emphasis was placed on studies on the biology and control of biting flies in Ontario. Further data were obtained on the population dynamics of *Culex* spp. in southwestern Ontario and on development of artificial oviposition sites (plastic wading pools) in order to monitor *Culex* populations. A study was begun to determine if it is feasible to forecast *Aedes* spp. development and emergence utilizing phenological stages of selected plant species as indicators of when *Aedes* adults are emerging and hence when insecticide treatments should be applied. In control studies, the pyrethroid insecticide, permethrin, showed excellent potential as a residual spray for backyard mosquito control. Three insecticides showed promise for control of mosquito larvae and pupae - the pyrethroid insecticide, cypermethrin; the chitin inhibitor, Bay SIR 8514; and *Bacillus thuringiensis* var. *israelensis*. A Guelph subdivion was selected as a model site for a study of management of mosquito populations using a pest monitoring program to assist in scheduling insecticide applications. Altosid(R) was applied to breeding sites (catch basins) when monitoring data indicated the presence of larvae. Adult emergence was reduced by ≥90% for 10 weeks (19).* Further research was supported to

*Numbers in brackets refer to Abstracts included in Appendix III.

assess the feasibility of using Planaria to control mosquitoes breeding in catch basins. More information was obtained in laboratory and field studies, on the biology of a native Planarian, *Dugesia tigrina*; on its effectiveness against *Culex* larvae in catch basins; and on its survival under adverse conditions (7). In blackfly studies, laboratory and field tests were continued with the aim of finding effective, safe economical methods of control. Diflubenzuron, temephos and chlorpyrifos-methyl continued to show promise for black fly control. Some other invertebrates were also affected by these insecticides at practical rates of application (9).

Structural household pests are a major concern in Ontario and large quantities of pesticides are used to control them. Cockroaches are not only a nuisance, but also can be carriers of disease. They are difficult to control and have developed resistance to insecticides in many places. In a study begun in 1979, two cultures were established from apartments and from a restaurant in Toronto and baseline toxicity data were obtained. When these data were compared to results obtained with a susceptible German cockroach strain, it was apparent that the apartment and restaurant strains had developed low level resistance to some OP and carbamate insecticides, but not to the pyrethroid insecticides (2).

Objective 2: To determine potential environmental hazards with pesticides presently in use.

Seven grants totalling $45,500 were related to this objective.

Research on the fate of pesticides in the environment was continued. Laboratory and field studies indicated that the carbamate insecticide, aldicarb, is degraded in soil to aldicarb sulfoxide and aldicarb sulfone. Insecticidal activity and persistence in soil was influenced by soil type, i.e. the insecticide was less toxic and more persistent in organic as compared to mineral soil. Under field conditions, aldicarb disappeared from soil in 4-6 weeks. No detectable residues of aldicarb, a.sulfoxide, or a. sulfone were present in either mineral or organic soil by fall (3). Laboratory and field studies also indicated that the carbamate insecticide, carbofuran, degrades relatively quickly in mineral and organic soils. Under field conditions, carbofuran had a half-life of ca. 1.5 weeks in sand and ca. 2 weeks in muck. Soil microbes played a major role in degrading carbofuran. The metabolites 3-hydroxycarbofuran and 3-ketocarbofuran degraded quickly in soil (12). A study on the fate of mercurial fungicides used to control disease in turfgrass was completed on two golfcourses which had been subjected to mercurial fungicide treatments for a number of years. Vertical movement of mercury through the soil was minimal, but lateral movement from the treated sites was quite extensive. The results suggest that prolonged use of mercurial fungicides on golf course greens has the potential to pollute water in lakes or streams up to 30 m from the treated area (6). Research also was completed on design of a computer model of the behaviour of the herbicide, diquat, in soil using data obtained from laboratory and field experiments and from published data on the biological and chemical reactions of diquat. The results of the modelling process indicated: that photolysis and adsorption are the most important factors affecting the persistence of diquat in water; that diquat will leach in sediment to a limited extent; but that accumulation of high diquat concentrations from normal field application rates is unlikely to be a problem (10).

The potential of pesticides to affect non-target terrestrial and aquatic organisms received further attention. New studies were initiated to assess the effects of insecticides used for insect control on corn to honey-bees (17) and on the effects of the aquatic herbicide Aqua-Kleen(R) (2,4-D) on non-target aquatic microflora (4). Research was continued on the effects of pesticides, especially 2,4-D and its derivatives on rainbow trout: 96 hour LC_{50} values were obtained for several herbicides. Weedone(R) was most toxic > dichlorprop>diphenoprop>Brushkiller 96(R) (11).

Objective 3: To reduce total pesticide input into the environment.

Ten grants totalling $81,270 were allocated to this objective.

Pesticides are often applied as "insurance treatments", i.e., the grower is not sure that the pest will be present at a level high enough to cause serious damage, but cannot take the risk that this will occur. Thus it is important to obtain information on the economics of pest control. In a study conducted over two years, the economics of implementing a monitoring system as an aid in controlling the onion maggot in the Holland Marsh was investigated. The net benefit to a grower adopting the monitoring system was ca. $20/acre as compared to a grower following a conventional control program. Nevertheless, growers hesitate to adopt the monitoring program since they consider that the risk of sustaining higher onion maggot damage is greater than with the conventional maggot control program. It was suggested that greater emphasis be placed on educating growers to understand the benefits of pest monitoring programs (14). Further data were obtained on the effects of the spotted tentiform leafminer on apple trees. This pest attacks only the leaves - the fruit are not directly affected. However, significant reductions in the net rate of photosynthesis occurred with increasing leafminer populations. The results suggest that high levels of leafminer activity over the growing season would reduce economic yields (15).

Development of effective pest monitoring techniques would often result in more effective pest control, with a significant reduction in pesticide use, i.e., with pesticide applications timed to the appearance of the pest there would be no requirement for the so-called "insurance" applications. The Advisory Committee considers this to be one of the most practical approaches to reducing pesticide input into the environment, has supported development of pest monitoring programs since the inception of the research program, and continued to do so in 1980-81. Research on apple pest management was begun in 1969. The program developed from the research to demonstration stage over the next 10 years and by 1979 was ready for implementation on a larger scale. Through cooperation between the Ontario Apple Commission, Lottario, and the Pesticides Advisory Committee, a 3-year large-scale demonstration program was initiated in 1980. Results of the first year's work will be available in May, 1981 (13). Similar emphasis has been placed on development of monitoring programs for vegetable insect pests, especially pests of onions and carrots. Further research on development of weather-timed fungicide schemes for vegetable crops was supported in 1980-81. Preliminary work on development of a small, battery-powered system capable of recording data, e.g. soil and air temperatures, leaf wetness duration, and computing and displaying degree days (for insect management) and wetness periods and average temperature of the wetness period (for disease management) was begun. In field trials several fungicides were tested using prophylactic and weather-timed spray schedules for control of

diseases of onions and carrots (8). A new study was funded to assess the feasibility of using pheromone traps to monitor low density populations of spruce budworm. Development of such a technique would allow early detection and possible suppression of such outbreaks, requiring smaller, more localized control operations than are now necessary, and, possibly, methods of population regulation other than conventional insecticides. Moth populations were considerably higher than expected in 1980 and traps became saturated with moths making it difficult to correlate size of catch with larval densities. A new trap with higher capacity effective over a wide range of population densities is being designed (16).

Current pesticide application techniques leave a great deal to be desired - more efficient methods of application would result in better pest control with less environmental contamination. The Advisory Committee has funded several studies leading to development of better application methods. In 1979, a proposal to compare herbicide application methods using three new "sprayer" designs was supported. Two types of wick applicators and a roller applicator were tested for application of herbicides to weeds growing above a crop. Good results were obtained with all three applicators, all of which have many possible applications, particularly for controlling perennial weeds in shorter row crops (22). In two other studies, begun in 1980, the effect of spray volume and droplet size on the efficacy, persistence, and movement of herbicides was assessed (1, 18).

Non-chemical methods of pest control may be practical in some situations. As noted earlier, promising results were obtained in mosquito control studies using B. thuringiensis var. israelensis (19) and the flatworm D. tigrina (7). Another non-chemical approach, widely advocated by organic gardeners is to use companionate plantings. A study to evaluate the effects of companionate plantings on pests in the home garden was initiated in 1979. Results obtained in both 1979 and 1980 have thus far failed to substantiate popular claims that companion plants repel insects and disease organisms. Despite reductions in pests in some companion-crop associations, these reductions were not usually below the economic threshold. Competition between vigorous companion plants may reduce crop yield. Though acceptable yields of cabbage and potatoes were realized without pesticides, the quality was substantially poorer than that in sprayed plots (21). A study was begun in 1980 to assess the feasibility of using parasites and/or predators of the onion maggot in an integrated control program. Thirty-seven parasitoids of the onion maggot were identified; a mass rearing technique was developed for one of the parasites; and a small field release of parasites was made at the Thedford Marsh in the fall of 1980. The occurrence and frequency of onion maggot parasitoids in the three major onion growing areas in Ontario, i.e. under heavy insecticide pressure, was compared with an untreated area at London, Ontario. With one exception, parasitoid activity was lower in the marshes, than in the untreated area at London (20).

ASSESSMENT

Within the first research objective, continued good progress is being made on control of biting flies. Information on the biology of important species of mosquitoes is being developed; techniques for locating breeding sites and for monitoring mosquito populations have, or are being devised, and effective control programs for both mosquitoes and blackflies are being worked out. While the broad spectrum pyrethroid insecticides are very effective

for biting fly control, it also is encouraging to note that narrow spectrum chemicals, such as the chitin-inhibitors show promise; and also, that biological control agents are showing some promise for mosquito control. Development of integrated control programs for mosquitoes will take longer, but as indicated in one 1980 study, the timed applications of control agents in conjunction with population monitoring may be feasible in some circumstances. In contrast to the promising progress being made on biting fly control, the lack of data available on the biology and control of structural and household pests is very apparent. Projects supported by the Advisory Committee over the past four years have begun to fill in some information gaps. Nevertheless, our knowledge of the biology of this group of pests is inadequate; there are few alternatives to the chemicals currently recommended for use; and these options will be even more limited as pests such as cockroaches develop resistance. Continued emphasis will have to be placed on development of less persistent, less hazardous chemicals, and of integrated methods of control for important structural, household, agricultural and forestry pests.

Under the second objective, good progress has been made in the past decade in defining the fate and behaviour of insecticides in the Ontario environment. OC insecticides are declining in agricultural soils in Ontario. Research has shown that OP, carbamate and pyrethroid insecticides are subject to microbial and/or chemical degradation in soil and water, and that they are not accumulating in mineral soils or water to any significant extent. Insecticide residues are being detected at relatively high levels in organic soils, but progress is being made in developing pest monitoring techniques and alternative approaches to insect control which will ultimately lead to a decline in insecticide residues in organic soils. Some of the newer insecticides being introduced are relatively soluble in water - a factor which should be taken into consideration in environmental studies. Research data also suggest that the effects of insecticides currently in use on non-target flora and fauna will be transitory. Less emphasis has been placed on environmental studies with fungicides and herbicides and more research on the fate and behaviour of these chemicals in the environment is justified.

The Pesticides Advisory Committee feels that priority should be assigned to the third research goal, i.e., of reducing pesticide input into the environment, while still achieving as good as, or more effective pest control. Good progress is being made in developing crop loss data, economic thresholds of damage, and pest monitoring techniques. Such studies, as well as research on better methods of application and integrated pest control merit strong support.

The Pesticides Advisory Committee is pleased with the research progress made in 1980-81 and recommends continuation of the program. Part of the success of the program is due to the fact that it has been deliberately kept small allowing committee members, all of whom have other full-time responsibilities to administer it with a minimum of effort. The Committee feels that this approach should be maintained. In doing so, it recognizes that, with the limited funds available, the program can be expected to act only as a catalyst in stimulating research in the broad areas indicated in the guidelines, for which there is still an urgent requirement.

IV REFERENCES CITED

Ontario Pesticides Advisory Committee. 1974. An assessment of pesticide research projects funded by the Ministry of the Environment through the Ontario Pesticides Advisory Committee, 1973-74. 33 p.

1975. An assessment of pesticide research projects funded by the Ministry of the Environment through the Ontario Pesticides Advisory Committee, 1974-75. 36p.

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1979. An assessment of pesticide research projects funded by the Ministry of the Environment through the Ontario Pesticides Advisory Committee, 1978-79. 42 p.

1980. An assessment of pesticide research projects funded by the Ministry of the Environment through the Ontario Pesticides Advisory Committee, 1979-80. 50 p.

APPENDIX I. Format of advertisement inviting applications for research support from the Ontario Pesticides Advisory Committee.

January, 1980

APPLICATION FOR RESEARCH SUPPORT

The Ontario Ministry of the Environment has a limited amount of funds available for 1980 to sponsor research aimed at: 1) determining potential environmental hazards associated with pesticides currently in use; 2) developing alternative pesticides for those deemed environmentally hazardous and thus restricted in use:; and 3) developing alternative approaches to pest control in order to reduce total pesticide input into the environment. Preference will be give to proposals yielding results in a relatively short time with funds being committed on a yearly basis. Research should be in the context of normal use patterns.

The Ministry invites research proposals in the following areas:

1. Economics of pest control including economic threshold levels of pests.*
2. Studies leading to registration of environmentally acceptable pesticides.
3. Reduction of pesticide use through development of effective pest monitoring techniques; alternative integrated or non-chemical methods of control; or improved application techniques.
4. Studies on the persistence, fate, and biological significance of pesticides in the environment, with particular reference to pesticides widely used in Ontario.
5. Development of information on time which should elapse between dates of treatment and re-entry into treated areas, and on exposure of agricultural workers and licensed exterminators to pesticides.
6. Development of procedures for safe disposal of pesticides and pesticide containers.

*In the Pesticides Act, 1973, S1(1)20, a "pest" means "any injurious, noxious or troublesome plant or animal life other than man or plant or animal life on or in man and includes any injurious, noxious or troublesome organic function of a plant or animal."

APPLICATION PROCEDURE

Research proposals should be submitted to:

The Chairman
Pesticides Advisory Committee
Queen's Park
TORONTO, Ontario M7A 1A2

Applications should include the following:

1. Title of project
2. Name, address and affiliation of applicant(s)
3. Discussion of problem (Applicants applying for continuation of a grant should include a summary of previous progress)
4. Clear statement of objective(s)
5. Plan for program
6. Facilities available
7. Budget - categorize costs as: Personnel - full time and part time, equipment, supplies, overhead costs, other
8. Listing of current projects and other sources of funding
9. Curriculum vitae on principal investigator(s) (if not already on file with the Pesticides Advisory Committee).

Applications should be received by February 28, 1980.

APPENDIX II. Research Projects Supported by the Ontario Pesticides Advisory Committee, 1980-81

No.	Applicant	Location	Project Title	Amount Granted
1.	Anderson, G. W.	University of Guelph	The efficacy of controlled droplet applicators for herbicides	$ 7,000.00
2.	Blaine, W. D.	Chemical Research International	A study of resistance by the German Cockroach *Blattella germanica* (L.) in the Toronto area to insecticides and the effectiveness of these chemicals in control	5,000.00
3.	Chapman, R. A. Harris, C. R.	University of Western Ontario	Behaviour of aldicarb (Temik(R)) in soil.	9,000.00
4.	Coleman, B.	York University	The dynamics and persistence of the herbicide Aqua Kleen (2,4-D) and its impact on non-target aquatic microflora	3,000.00
5.	Ellis, C. R.	University of Guelph	The economic significance of potato leaf-hoppers in new seedings of alfalfa	6,500.00
6.	Fushtey, S. G.	University of Guelph	Fate of mercurial fungicides used to control disease in turfgrass	8,000.00
7.	George, J. A.	University of Western Ontario	Control of mosquitoes in Ontario with Planarian flatworms	12,000.00
8.	Gillespie, T. J.	University of Guelph	Weather timed fungicide schemes for vegetable crops	7,500.00
9.	Kaushik, N. K.	University of Guelph	Effects of insect growth regulators and new candidate larvicides on blackfly larvae and non-target aquatic invertebrates	5,500.00
10.	Mayfield, C. I.	University of Waterloo	Diquat in aquatic systems	1,000.00

APPENDIX II Cont'd...

No.	Applicant	Location	Project Title	Amount Granted
11.	Mayfield, C. I.	University of Waterloo	The behavioural toxicology of sublethal doses of aquatic pesticides as revealed by the modification of rheotropism in rainbow trout, *Salmo gairdneri*.	$ 10,500.00
12.	Miles, J. R. W. Tu, C. M.	University of Western Ontario	Microbial degradation of carbofuran in soil	6,000.00
13.	Ontario Apple Commission	Mississauga, Ontario	Investigation of new pests in pest management	7,500.00
14.	Pfeiffer, W. C. Stemeroff, M.	University of Guelph	The economic benefits to growers of pest monitoring in onion & carrot production in the Holland and Keswick marshes	8,000.00
15.	Proctor, J. T. A. Laing, J. W.	University of Guelph	Determination of the physiological thresh-hold for control of the spotted tentiform leafminer on apple trees	7,500.00
16.	Sanders, C. J.	The Sault College of Applied Arts and Technology	Development of sex attractant traps for monitoring changes in low density spruce budworm populations as a means of implementing early intervention management strategies	13,000.00
17.	Smith, M. V.	University of Guelph	Honeybee poisoning hazards on sweet corn in Ontario	8,000.00
18.	Stephenson, G. R.	University of Guelph	Reduction of herbicidal drift with a micromax field crop sprayer	4,000.00
19.	Surgeoner, G. A. Helson, B. V.	University of Guelph	The biology and control of mosquitoes and other biting flies in Ontario	50,000.00

APPENDIX II Cont'd...

No.	Applicant	Location	Project Title	Amount Granted
20.	Tomlin, A. D. Tolman, J. H.	University of Western Ontario	Feasibility of using parasites and/or predators in a program of integrated control of the onion maggot	$ 12,000.00
21.	Wukasch, R. T.	University of Guelph	Effect of companion planting on pests in the home garden	8,270.00
			TOTAL:	$ 199,270.00

APPENDIX III. Progress reports (Abstracts) on projects funded by the Ontario Pesticides Advisory Committee, 1980-81

1. Mason, W. M. A. and Anderson, G. W. - The efficacy of controlled droplet applicators for herbicides.

Growthroom and field trials were conducted to determine the effects of controlling droplet size and reducing carrier volumes for soil applied herbicides. CDA's (controlled droplet applicators) were used to apply atrazine, EPTC, and trifluralin in a series of volumes ranging from pure formulation to 40 l/ha. Droplet size for the growthroom trials ranged from 140μ to 2100μ VMD (volume median diameter). Equipment allowed a droplet size range of 40μ to 175μ VMD in the field trials. Conventional fan nozzles (8002LP) were used to apply rates of 120 l/ha and 227 l/ha. The same level of active ingredient per hectare was maintained for each chemical over all volumes of carrier. The herbicides were applied ppi (pre-plant incorporated) in both the growthroom and field. Oats var. Elgin and barley var. Perth were used as indicator species. Dry weights were taken. A pre-emergence trial of atrazine was conducted in the field with visual ratings done on the weed populations. No indicator species were seeded for the pre-emergence trial of atrazine. Results indicate that volumes as low as 2.5 l/ha perform equal to or better than conventional volumes of 120 l/ha and 227 l/ha for the ppi and pre-emergence atrazine and the ppi EPTC over a wide range of droplet sizes. Volumes of 7 l/ha were not significantly different from 120 l/ha and 227 l/ha with trifluralin in the growthroom. Droplets less than 200μ VMD generally did not perform as well as larger droplets at volumes of 7 l/ha, 10 l/ha, and 35 l/ha trifluralin. At 2.6 l/ha and 4 l/ha the smaller droplets generally resulted in better control than droplets larger than 200μ VMD. In the trifluralin field trials, 21 day harvests suggested no difference between the CDA and conventional volumes. At 45 days and 90 days, 25 l/ha was the lowest volume not significantly different from 227 l/ha. Soil samples were taken from the atrazine field trial and maintained in the growth room for two months prior to initiating a residue bioassay. Oats var. Elgin were used as indicator species. Volumes of 2.5 l/ha, 7 l/ha, and 4 l/ha gave significantly more residual activity than 28 l/ha, 15 l/ha, or 227 l/ha, regardless of droplet size. 28 l/ha and 15 l/ha were not significantly different over the droplet range of 130μ to 143μ VMD. With larger droplets, 28 l/ha performed significantly better than 15 l/ha. Two growth room trials were conducted to study the efficacy of similar herbicides applied with a CDA. Pendamethalin and trifluralin, and atrazine and simazine were compared. At all volumes applied with the CDA, pendamethalin performed significantly better than trifluralin. Similarly atrazine performed significantly better than simazine at all volumes applied with the CDA. There was no significant difference at 227 l/ha in either case.

2. Blaine, W. D., Siddiqui, Z., and Cameron, R. - A study of resistance by the German cockroach, *Blatella germanica* L. in the Toronto area to insecticides and the effectiveness of these chemicals in control.

Three strains of the German cockroach, *Blattella germanica* (L). were cultured to carry out resistance testing. One strain had not had any exposure to pesticides for approximately 20 years. The second strain was collected from three apartment buildings in the city of Toronto and the third strain was collected from a single restaurant. The pesticides

Baygon, Diazinon, Dursban, Ficam, Vapona, Pyrocide, D-Trans-Allethrin, Resmethrin and Cypermethrin were applied topically. Resistance levels were then determined statistically. Resistance to the organophosphates and carbamates was widespread but little resistance to the synthetic pyrethroids was found.

Susceptibility of adults of the University and Apartment strains of German cockroach, <u>Blattella germanica</u> (L). to direct contact application of insecticides.

Insecticide	Sex	LD_{50} µg/individual with fiducial limits				Resistance Ratio
		Apartment Strain		University Strain		
Baygon	M	3.39		1.02		3.3
		2.51	4.33	0.78	1.34	
	F	4.65		1.94		5.9
		2.92	6.63	1.38	2.65	
Ficam	M	2.54		0.31		8.2
		1.89	3.63	0.24	0.39	
	F	could not be calculated		1.31		could not be
		48% kill at 5.00%		1.13	1.57	calculated
Diazinon	M	5.68		0.74		7.7
		4.31	7.57	0.46	1.01	
	F	10.12		2.34		4.3
		8.18	13.03	1.57	3.52	
Dursban	M	2.47		0.66		3.7
		1.81	3.80	0.50	0.91	
	F	5.18		0.52		10.0
		4.07	7.07	0.34	0.74	
Pyrocide	M	1.55		1.01		1.5
		1.46	2.25	0.85	1.45	
	F	7.70		2.28		3.4
		5.70	10.60	1.60	3.28	
D-Trans Allethrin	M	0.72		0.32		2.2
		0.60	0.83	0.25	0.40	
	F	1.48		1.34		
		1.33	1.64	1.03	1.72	1.1

3. Chapman, R. A., and Harris, C. R. - Behaviour of aldicarb (Temik$^{(R)}$) in soil.

Aldicarb, a highly toxic systemic carbamate insecticide, is one of the most effective insecticides available for control of insect pests attacking potatoes, and it is being used on both mineral and organic soils by increasing numbers of potato growers each year. The insecticide is very soluble in water and recent studies in the United States have indicated that low levels of aldicarb are present in well water in areas, such as Long Island, where it has been used extensively for potato insect control.

During 1980, laboratory and field studies showed that aldicarb is degraded to aldicarb sulfoxide and aldicarb sulfone in mineral and organic soils under conditions encountered in southwestern Ontario. Laboratory tests indicated that all three compounds were toxic, broad spectrum insecticides, with aldicarb generally being more toxic than the sulfoxide and sulfone. Aldicarb was also very active when incorporated in moist mineral soil; the sulfoxide and sulfone were much less active. Insecticidal activity in soil was influenced by soil type, moisture, and temperature. In microplot field tests aldicarb, applied to mineral and organic soil at 3.4 kg AI/ha, disappeared from the soil in 4-6 weeks. Between 30-50% of the initial aldicarb applications were converted to the sulfoxide, with the maximum concentration observed within three weeks after treatment. Maximum sulfone concentrations were <10% of the initial applications. Both the sulfoxide and sulfone were more persistent in organic as compared to mineral soil. However, no detectable residues of aldicarb or its metabolites were present in soil by fall. The rapid disappearance of the sulfoxide and sulfone may have been related to the fact that heavy rains during the summer resulted in flooding of the plots several times. Considering the solubility of aldicarb and its metabolites in water, we suspect that the residues were leached below the 15 cm sampling depth. Total aldicarb residues were <0.05 ppm in carrots grown on the treated plots.

4. Birmingham, B. C., Thorndyke, M., and Colman, B. - The dynamics and persistence of the herbicide Aqua Kleen$^{(R)}$ (2,4-D) and its impact on non-target microflora.

Six 5 m square ponds were established in 1980, planted with *Myriophyllum spicatum* in 2,4-D-free garden loam, and Aquakleen was applied at 20 lb active ingredient per surface acre to three of these ponds once the plant populations had stabilized. Initial levels of BEE in pond water were low (0.16 μg/l one day after application) decreasing to less than 0.01 μg/l within 15 days. This rapid disappearance of the ester is a reflection of both its low water solubility (12 mg/l) and its rapid hydrolysis to the free acid form of 2,4-D. Over the same period the 2,4-D acid level in pond water rose to 3 mg/l and this gradually decreased to about 1 mg/l after 85 days and 0.2 mg/l after 178 days. The ester persisted much longer in the pond sediment rising to about 1.7 mg/g dry wt one week after treatment then rapidly decreasing to <0.1 mg/g dry wt after 7 weeks. Initial levels of 2,4-D acid were high in the sediment hydrosoil (6.7 mg/g dry wt) one day after treatment and then dropped to the levels found in the pond water. Thereafter, 2,4-D acid residues in the sediment were similar to and paralleled pond water levels. Dramatic increases in 2,4-D residues taken up by plant material were observed during the 2 weeks following treatment. A mean maximum level of 206 mg/g dry wt plant material was observed nine days after treatment. This represents 2,4-D taken up by *Myriophyllum spicatum* because residue levels dropped to 10-20 mg/g dry wt after this period.

No significant temperature differences were observed in surface waters of control and treated ponds. Mean water temperature of the ponds dropped from 25°C at treatment to freezing temperatures within two months and the ponds were frozen for the remainder of the study. The last sample (residue analysis) was obtained 178 days after treatment just after spring thaw. Significant decreases in the level of dissolved oxygen and pH and a significant increase in dissolved inorganic carbon occurred in treated ponds about one week after herbicide application. These changes were caused by the death of the actively photosynthesizing water weeds. No significant differences were observed in levels of dissolved organic nitrogen (Kjeldahl), free ammonia, nitrate or total soluble phosphate in water from control or treated ponds. Levels of nitrate in both sets of ponds were exceedingly low (<10 μg/l) during the month following treatment. This may be related to the vigorous growth of filamentous green algae that occurred during this period. There was no evidence of massive release of dissolved nutrients following death and decay of water weeds. Unicellular algae did not bloom and the ponds remained transparent throughout the study. Chlorophyll a readings exhibited "pre-bloom" values (mean values of 1-4 μg/l with a single pond maximum of 11 μg/l). Phaeophytin values were very high generally exceeding 50% of the chlorophyll a readings and suggested heavy grazing by the zooplankton.

Significant invasion of the water weeds in control ponds by filamentous green algae i.e. 10-50% coverage, occurred 4 to 7 weeks after treatment started. In the treated ponds, *Myriophyllum* collapsed to the pond bottom 5 days after herbicide application. Filamentous algae developed on the dead water weeds and had completely invaded the ponds three weeks after treatment. Initial phytoplankton populations in the ponds were dominated by a diverse assemblage of unicellular green algae and a few species of blue-green algae. The initial mean algal cell densities were similar in both control and treated ponds and decreased somewhat in the three weeks following treatment. Over the period three to seven weeks after treatment, the mean cell density increased dramatically in control ponds mainly due to the blue-green alga *Rhabdoderma irregulare*. This increase was not observed in treated ponds. In the ensuing seven to twelve week period until the ponds froze algal cell densities were similar in both control and treated ponds. Zooplankton in the ponds consisted of rotifers, cyclopoid copepods, cladocerans, ostracods and insect larvae (mainly *Chaoborus*). Though copepods formed 30-40% of zooplankton these were mainly juvenile stages (nauplii and copepodids). Adult copepods rarely exceeded 3% of the total zooplankton probably due to the presence of *Chaoborus* larvae which actively select copepods over cladocerans in their diet. Initial zooplankton numbers in control ponds were significantly higher than in treated ponds in the two weeks following treatment. This was mainly due to population peaks of ostracods one week after treatment and rotifers the following week. These ostracod and rotifer population maxima were not observed in treated ponds. The population densities were similar on both sets of ponds during the period three to five weeks after herbicide application. Zooplankton densities then began to decline in treated ponds but not in controls. This decline in zooplankton numbers in treated ponds was mainly due to the virtual absence of rotifers and ostracods and a substantial reduction in copepod and cladoceran populations.

5. Ellis, C. R. - The economic significance of potato leafhoppers in new seedings of alfalfa.

Report not available.

6. Fushtey, S. G., and Frank, R. - Fate of mercurial fungicides used to control disease in turfgrass.

Samples of grass and soil in increments down to a depth of 60 cm were collected from a green and adjacent areas on each of two golf courses in southwestern Ontario where the greens had been receiving mercurial fungicides for disease control for a number of years. Analysis of these samples for mercury content showed that movement downward into the soil varied from a maximum depth of 30 cm at one site to a maximum depth of 60 cm at the others. The difference seemed to be related to a difference in soil structure, namely that the former site had a higher proportion of clay particles in the upper soil layers. Levels of mercury residue in excess of background were found up to 30 m distant from the treated areas at both sites. The distribution of these residues was not related to surface drainage patterns. Samples taken up to 20 m uphill from the greens yielded residue levels similar to those taken 20 m downhill. The means by which mercury moved laterally was not clear but the results presented indicate that prolonged use of mercurial fungicides on golf course greens has the potential of polluting water in lakes or streams up to 30 m distant from the treated area.

7. George J. A. - Control of mosquitoes in Ontario with Planarian flatworms.

Three years of identifying mosquito larvae for the Middlesex County Health Unit survey teams has helped to establish catch basins as major breeding sites for *Culex* sp. Meanwhile, the flatworm *Dugesia tigrina* has been shown to prey heavily on mosquito larvae but it does not occur in catch basins unless introduced. In 1980, therefore, tests were initiated to determine the proportion of catch basins with *Culex* larvae that *D. tigrina* will survive in.

On July 15, 1980 ca. 80 planaria were placed in each of 31 selected catch basins with a styrofoam float to enable monitoring of planaria. Four catch basins had to be withdrawn either because oil was added or the floats were removed. On Oct. 31, 1980, planaria were found in all but one of the remaining 27 catch basins and the number of planaria per float ranged from one to 178 with an average of 34.

In replicated, 30 day, laboratory tests, there was an average of 32 planaria per float whether there was a total of 75, 150 or 300 planaria per 12 liter container.

Culex egg rafts, with known numbers of eggs, were placed in simulated catch basins with no, or various numbers of, planaria. In the absence of planaria, densities of over 100 eggs per liter both severely limited the percentages of eggs that developed to adults and greatly increased the time required for adult emergence. Planaria were capable of preventing adult emergence when eggs were added at a rate of up to two eggs per day per planarian.

D. tigrina cannot survive the complete desiccation of temporary ponds which support spring and summer *Aedes*.

Many tests, and searches, failed to reveal the presence of tiny *Merostoma* spp. planaria found to effectively control mosquito larvae in California rice fields.

The life history of local *D. tigrina* was determined. Individuals produce from 28 to 30 buds asexually over a lifetime of 9 to 10 months at 21°C and then die. Individuals increase in size to about 2.5 cm at from five to six months of age and then decrease in size until death. Just prior to death rapid

budding occurs until only the triangular head remains. As it cannot feed, the head soon dies. A publication on the life history is in print.

Giant planaria were obtained by coating rearing containers with petroleum jelly. Such a coating halted budding but not feeding or growth. A publication on giant planaria is in print.

A biochemical means of measuring the biomass of individual planaria was devised and evaluated.

D. tigrina were not affected by feeding on moribund mosquito larvae killed by protein inclusions of Bacillus thuringiensis var. israelensis.

Finally, road salt killed all planaria at .56%, but only killed half of the Culex at 0.75%.

8. Gillespie, T. J., and Sutton, J. C. - Weather-timed fungicide schemes for vegetable crops.

(a) Development of weather-monitoring instrumentation for use by growers in pest management: Several small, battery-powered systems capable of recording data pertinent to pest monitoring have been investigated. Requirements for the system were established as: continuously monitor air and soil temperatures and leaf wetness duration; compute and display degree days above several programmable base temperatures (for insect management); and compute and display wetness periods and the average temperature of the wetness period (for disease management). Modification of some existing systems from the U.S. to meet the above requirements was considered, but abandoned due to cost and/or difficulties in communication with the manufacturers. We are therefore presently tooling up to program microprocessor chips ourselves, and have identified two Canadian companies interested in commercial production of the proposed device. Field testing will take place during the 1981 growing season.

(b) Development of an integrated spray program for Botrytis leaf blight and downy mildew in onions: Efficacy and timing of Ridomil and Bravo for control of downy mildew and Botrytis was examined in field plots at the Arkell Research Station. A full range of weather variables was monitored in the onions throughout the season by sensors linked to a computerized micrologger. Sources of initial inoculum were infected plants (downy mildew) or naturally occurring sclerotia (Botrytis). The following foliar treatments were applied: (1) Ridomil at 14-day intervals; (2) Ridomil, weather-timed; (3) Bravo, weather-timed; (4) Ridomil at 14-day intervals plus Bravo, weather-timed; (5) Ridomil, weather-timed, plus Bravo, weather-timed; (6) Ridomil and Bravo, tank mix, at 10-day intervals; (7) nonsprayed check plots, located remotely from sprayed plots.

Bravo failed to control downy mildew. Downy mildew progressed almost as rapidly in plots only with Bravo (3) as in check plots. Bravo did not increase efficacy of Ridomil in controlling mildew. All treatments with Ridomil and especially treatments, 2, 4 and 5 reduced rates of development of downy mildew, but all onions eventually succumbed to mildew largely because of enormous inoculum doses from nearby plots. Little Botrytis developed before the mildew outbreaks. No residues of Ridomil were found in onions harvested from plots variously treated with Ridomil.

(c) Effectiveness of the systemic fungicides Bayleton and CGA-64250 in controlling late-season development of leaf blights in carrots: In field plots at the Muck Research Station, disease intensity (mid-canopy, 19 September) in carrots treated with no fungicide, Maneb 80WP (3.4 kg AI/ha), Bayleton 50WP (250 g AI/ha) and CGA-64250 (174 g AI/ha) was 22, 7, 4 and 1%, respectively. Fungicides were applied on 6 and 20 August and 3 September. Both systemics were highly effective against both Alternaria and Cercospora blights.

9. Rodrigues, C. S., and Kaushik, N. K. - Effects of insect growth regulators and new candidate larvicides on blackfly larvae and non-target aquatic invertebrates.

This project was primarily designed to study the effects of some of the suggested larviciding agents and insect growth regulators on the emergence of black fly larvae and on non-target stream invertebrates. The programme during the year included examination of benthic samples collected during the treatment of three streams with Dimilin and to design and construct a laboratory stream suitable for experimentation with black fly larvae.

Field trials had been carried out during 1979 in three streams in the Adirondack mountains to record the effect of 1 ppm of Dimilin (25% WP) applied for 30 minutes. Average reduction in the Simulium larval population in the three streams 15 days after the treatment was 91.1%, 96.8% and 99.4% at distances of 837 m, 585 m and 165 m from the treatment point respectively. Non-target stream invertebrates were collected by drift nets, Surber sampler, kick samples and rock samples. The Surber sample data from Buck Creek showed that there was over 90% reduction in the Simulium larval population thus confirming the earlier findings. Also, analysis of benthic samples indicated that the chironomid population was adversely affected as based on Surber and rock samples, which showed more than 90% reduction in Buck Creek. Counting of benthic samples is still in progress.

With the new artificial stream, laboratory tests were conducted at different temperatures with two formulations of temephos (Abate 200E (EC) and Abate 50% WP) against Simulium larvae. With both formulations there was a strong positive correlation between water temperature and efficacy of the larvicide (<10% mortality at 10°C and >70% at 25°C with a dosage of 0.075-0.2 ppm/10 min). In contrast, chlorpyrifos-methyl 45.3% EC did not exhibit a strong relationship (16% mortality at 10°C and 48% at 25°C after exposure to 0.04 ppm/10 min). Experiments with Simulium larvae have shown that diflubenzuron is more effective at 25°C than at 10°C (<50% mortality at 10°C after 21 days and >92% at 25°C after three days, the dosage rate being 0.08 ppm/30 min).

Laboratory tests were conducted to test diflubenzuron against the amphipods Gammarus and Hyalella, the caddisfly Hydropsyche sp., the stone fly Acroneuria sp., chironomids and several species of mayflies. The effect on the amphipods was not much at 15°C (<25% mortality) but was significant at 25°C (>90% mortality). Of the other invertebrates, tests done at 15°C showed that the mayflies Baetis sp., Isonychia sp., and Paraleptophlebia sp., as well as chironomids, were susceptible (>65% mortality). Hydropsyche sp. (20°C) and Acroneuria sp. (15°C) were not affected (<6% mortality).

10. Mayfield, C. I. - Diquat in aquatic systems.

A computer model of the behaviour of the herbicide diquat in freshwater aquatic ecosystems has been constructed. The data for the model were obtained

from a series of experiments in sediment-water columns, small-scale ponds, and from published data on the biological and chemical reactions of diquat. The model was developed using the DYNAMO modelling language which uses the concept of a continuous modelling process and can simulate the "flow" of materials from compartment to compartment. The results of the modelling process, confirmed by experiments, show that photolysis and adsorption of diquat are the most important factors affecting the half-life of the herbicide in water bodies. The model also predicts that leaching of diquat in sediment will occur to a small extent, but that the accumulation of high diquat concentrations from normal field application rates is unlikely to be a problem.

11. Mayfield, C. I. - The behavioural toxicology of sublethal doses of aquatic pesticides as revealed by the modification of rheotropism in rainbow trout, *Salmo gairdneri*.

The toxicity of various derivatives of 2,4-D used as herbicides was determined with the standard 96-h toxicity test on rainbow trout. Briefly, the herbicides were applied to 30 rainbow trout between 35 and 75 mm in length and 0.5 to 3.0 g in weight at five different concentration levels. The fish were acclimated before exposure at a temperature of 13±2°C and were fed up until 2 days before testing. Only fish from groups with mortality rates less than 10%, 48 h prior to exposure were used in the experiments. A negative control group of 30 fish was also used. The herbicides were applied to aquarium tanks containing the fish so that the total load for each vessel was less than 1 g fish per litre. The standard test calls for aeration to be withheld during the 96-h exposure period during which time the mortality rates, pH, dissolved oxygen, partial or total loss of equilibrium and general behaviour of the fish are monitored. These factors are recorded after 6, 24, 48, 72, and 96 hours. Some tests were repeated with aeration to the tanks and the results compared to the same herbicide application without aeration.

The results obtained and analyzed by probit analysis to date indicate that the various herbicides have the following LC_{50} values in mg L^{-1};

Herbicide (or component)	LC_{50}
Brushkiller 96 (1:1)	22.5
Brushkiller 96 (2:1)	20.1
Diphenoprop	5.9
Dichlorprop (technical)	2.3
Weedone (2,4-DP)	1.9

In the cases examined, aeration of the systems decreased the toxicity of the herbicides to the rainbow trout.

12. Miles, J. R. W., and Tu, C. M. - Microbial degradation of carbofuran in soil.

In a laboratory study, the persistence of carbofuran and its 3-hydroxy and 3-keto metabolites was examined separately over 16 wk in sterile and natural organic (muck) and mineral (loam) soils. Carbofuran was relatively persistent in sterile soils; at 8 wk 77% remained in the sterile muck and about 50% remained in the sterile loam. In the natural muck 25% of initial carbofuran remained at 8 wk whereas in the natural loam carbofuran had completely disappeared by that time. The 3-ketocarbofuran was very short-lived even in the sterile muck wehre only 50% remain at 1 wk. The 3-hydroxycarbofuran degraded appreciably on zero day in the natural soils (with conversion to 3-ketocarbofuran)

and about 90% had disappeared in 1 wk. A more detailed study of the persistence of 3-hydroxycarbofuran in the natural soils showed complete disappearance in 2 days in loam and in 3 days in muck. The 3-ketocarbofuran produced from the 3-hydroxycarbofuran reached a maximum concentration in 1 day and then disappeared within 4 days in loam and about 1 wk in muck.

Carbofuran was applied to the surface of Plainfield sand and muck soils in field microplots at 3.36 kg/ha. After treatment, the soil of half the plots was raked to incorporate the carbofuran to about 7 cm into the soils. Analysis indicated a half-life for carbofuran in sand of 1.5 wk and in muck about 2 wk. In the surface treatment of the sand, 3 hydroxycarbofuran was formed within the 1st day, reaching a maximum (12% conversion) on the 2nd day and disappearing completely by the 3rd day. A trace of 3-ketocarbofuran (2%) was formed on the 1st day and persisted for about 2 wk.

13. Ontario Apple Commission. - Investigation of new pests in pest management.

A comprehensive report summarizing results obtained in 1980 is available on request.

14. Stemeroff, M., and W. C. Pfeiffer. - The economic benefits to growers of pest monitoring in onion and carrot production in the Holland and Keswick marshes.

Recent concerns over the numerous applications of pesticides with conventional methods have led to the introduction of pest monitoring for onion maggot control in the Holland and Keswick Marshes. Pest monitoring is offered as a complete alternative to conventional control whereby sprays are specifically timed for the most effective control results.

The purpose of this study was to examine the economics of the monitoring system for onion maggot control. Two phases were completed during 1980, namely; 1) an evaluation of the cost differential (net benefits) of pest control for growers using pest monitoring and growers with conventional control, and 2) an investigation of growers' decision processes regarding pest control alternatives.

Benefits from pest monitoring were considered only to be spray cost savings net of conventional control. Many growers using monitoring, reduced sprays by varied amounts depending on a variety of factors, (including weather, crop location, plant variety, etc.).

The costs of the present operational monitoring program in the marshes was calculated at $48,000/year (1979).

The cost differential (net benefit) for the average grower using monitoring was estimated at $19.91/acre per year (1979). This net benefit represented a 1.7% reduction in total cost (TC) or 2.7% reduction in total variable cost of production.

Although, given the clear potential for positive net benefits from monitoring of the onion maggot, growers have shown great reluctance in adopting the monitoring service. It was hypothesized, that growers' perceptions of "risk" were the key factor in explaining why the control alternative with the highest expected value (monitoring) was not selected.

Utility analysis was applied to the results of three focus group interviews. This investigation produced a reasonable explanation of the process by which growers decide between pest monitoring and conventional control. It was crucial to understanding the growers' behavior patterns when the net benefits from monitoring became known.

The expectation in this analysis was that when faced with "risk" growers may be reluctant to choose the alternative with the highest expected value, but tend to maximize expected "utility". The analysis of growers' general perceptions and attitudes highly favoured the selection of conventional control, because expected utility of conventional control was found to exceed that of monitoring. Growers' perceptions while identifiable were shown to be based on erroneous information about the two pest control alternatives. Even so the analysis clearly identified that selection of conventional control was the most rational given the reality of those perceptions.

Correct information regarding the nature of pest monitoring for control was discovered in only one case. This enlightened grower viewed the merits of monitoring closest to actuality. Thus, when applying this case to the utility model, expected utility of monitoring far exceeded that of conventional control. In this case, therefore the selection of monitoring was most rational and, in fact, that grower had accepted that approach.

The key to offering a monitoring program which growers would adopt lies in the transition of growers' attitudes about risk from the general case to the enlightened one.

It was recommended that a marketing plan be instituted, to "sell" and educate the growers on new ideas and perceptions about the riskiness of both conventional control and pest monitoring.

15. Bodnar, J., Proctor, J. T. A., and Laing, J. E. - Determination of the physiological threshold for control of the spotted tentiform leafminer on apple trees.

The spotted tentiform leafminer, Lithocolletis (Phyllonorycter) blancardella, F., is a major concern in Ontario's apple growing regions. As this pest attacks only the leaves, the fruit are not affected directly. However, harmful effects resulting from leafminer activity decrease the photosynthetic capacity of the overall tree.

Significant reductions in the net rate of photosynthesis were found as the leafminer population increased. Laboratory measurements of Delicious apple leaves (average area of 35 cm^2) had reduced photosynthetic rates up to 25% when 20 mines (average size of 0.55 cm^2) were included in the leaf. It would appear that relationships exist among mine populations, photosynthetic rates and specific leaf weights.

Several parameters are associated with the reduction in net photosynthesis due to leafminer activity. Chlorophyll content, stomatal conductance, specific leaf weight and mineral nutrition are adversely affected so as to limit photosynthate production.

As 90% of the dry matter in apple trees originates from the leaves, it is believed that high levels of leafminer activity over the entire growing season would reduce the economic yields presently being obtained. Moreover, persistent infestations would weaken orchard trees over subsequent years and result in an unthrifty status.

16. Sanders, C. J. - Development of sex attractant traps for monitoring changes in low density spruce budworm populations as a means of implementing early intervention management strategies.

Traps baited with synthetic sex attractant of the spruce budworm catch significant numbers of male moths when population densities are too low to be sampled practically by conventional means, such as egg and larval sampling.

The objective of this study is to develop the use of such traps for monitoring low density populations. This would allow the early detection and possible suppression of outbreaks, requiring smaller, more localised control operations than are now necessary, and methods of population regulation other than conventional insecticides.

Experiments were carried out in northwestern Ontario, the only region in eastern North American with extensive areas of low density populations, to correlate trap catches with population densities.

Six plots were selected, 4 in the vicinity of Black Sturgeon Lake (Nipigon District), 2 north of Dog Lake (Thunder Bay District). Population density was measured in each plot by collecting 100 branches from each of the 2 host species, balsam fir and white spruce, and examining them in the laboratory for larvae. In 2 of the plots a pupal sample was also taken, to give an estimate of mortality rates from which moth density could be predicted. Following this, traps coated on the inside with "tanglefoot" were placed out in each plot. The traps were in 2 groups of 5, one group having high potency lures, the other low. These were left out for the duration of the flight period (4 weeks) then collected up and the numbers of trapped males counted.

To allow meaningful correlations between catch and larval densities, the size and frequency distribution of the host trees were measured in each plot using a prism wedge and variable sized sub-plots. Trees of different sizes were then felled and branches were counted and measured at each whorl. The data were analysed by computer to calculate the regression of foliage surface area by diameter class, from which the total area of foliage/hectare was estimated.

Larval population densities were similar in all 6 plots. In 2 of them, which were also sampled in 1979, populations showed a tenfold increase over the year, possibly heralding the start of an outbreak in the region. Foliage surface area was measured on 47 balsam fir and 45 white spruce. Regression analysis showed that this provided an acceptable estimate of foliage on the smaller trees, but more data are needed for trees larger than 15 cm diameter (6 inches).

Unfortunately, the higher populations in 1980, resulted in the numbers of moths saturating the sticky trapping surface of all the traps, even those with the lower potency lures. Although further reduction in the potency of the lures could reduce catches to an acceptable level at this critical population density, this would restrict the range of densities over which the traps would be useful. A new trap design, with a higher capacity, effective over a wide range of population densities is therefore required.

17. Smith, M. V. - Honeybee poisoning hazards on sweet corn in Ontario.

Two study sites were set up near Lambeth and one at Millgrove, in areas where considerable sweet corn and field corn were grown. Honeybee colonies were moved into each of these locations, and were fitted with pollen traps and dead bee traps to assist in monitoring their foraging behaviour and to detect any

losses of field bees caused by pesticides.

Microscopic analysis of pollen samples indicated that no corn pollen was collected by the bees in the Lambeth area, and no bees were killed as a result of spraying with Sevin. In the Millgrove area, 10 to 14% corn pollen was found in the pollen traps in the early part of the season. One application of Furadan caused a minor loss of field bees, which did not result in any noticeable effect on colony strength.

It appeared that the bees showed a preference for collecting pollen from mustard, alsike, sweet clover, red clover, birdsfoot trefoil, goldenrod and aster, rather than from corn.

18. Stephenson, G. R., Smith, K., and Anderson, G. W. - Reduction of herbicidal drift with a micromax field crop sprayer.

A tractor mounted field crop sprayer was designed with four Micromax CDA units (battery driven, gravity fed, spinning discs) at 1.2 m intervals on a boom at a ht of 60 cm to a spray swath 11.6 m in width. Spray pressure was 69 kPa, the spray volume was 39 L/ha and the vehicle speed was 3.6 km/hr. The spinning discs were operated at low and high speeds to produce sprays dominated by droplets, 250 microns and 75 microns in diameter, respectively. Spray drift with these treatments was compared to that resulting from a conventional boom sprayer with 8002 nozzles at 20 cm intervals, a spray pressure of 310 kPa, a boom height of 45 cm, and a vehicle speed of 3.6 km/hr. Wind velocities of 6 to 21 km/hr were encountered in two different studies. The study was conducted in large open fields so that the vehicle path could be at approximate right angles to the wind. The "spray cloud" within, above, and downwind from the target area was intercepted on filter papers in petri dishes at 0.3 m intervals on 3 m poles positioned at 3 m intervals up to a distance of 42 m from the target area. Uridine (sodium fluorescene) and 2,4-D were applied at 0.5 and 1.0 kg/ha for later assay of droplet numbers (UV light) and cucumber root inhibition bioassay, respectively.

By either assay method the most drift was observed with 75 m droplet applications with the Micromax CDA sprayer. Droplet counts outside the target area revealed that Micromax applications with 250 m droplets drifted less than applications with the conventional sprayer. However, this was not confirmed in all cases by the cucumber assay method.

Possible limitations of the Micromax CDA approach include a tendency for the spray pattern to shift a short distance downwind and the necessity for low vehicle speeds. However, the ability to alter droplet size and thereby influence drift and pest control effectiveness is a promising advantage of this sprayer.

19. Surgeoner, G. A., and Helson, B. V. - The biology and control of mosquitoes and other biting flies in Ontario.

Evaluation of Insecticides as Residual Sprays for Backyard Mosquito Control.

Permethrin, malathion, iodofenphos, chlorpyrifos and methoxychlor were evaluated for their potential as residual lawn treatments by collecting 2 g of grass clippings from treated, 4 m^2 plots, placing these in cups containing ca. 15-20 mosquitoes and assessing mortality at 2 hr intervals thereafter. At recommended dosages, 80% mortality or more was achieved for 21-28 days with methoxychlor (2.08 g AI/m^2), 5-7 days with malathion (0.25 g AI/m^2), 5 days with

permethrin (0.00625 g AI/m^2), 2-5 days with chlorpyrifos, (0.09 g AI/m^2), and less than 2 days with iodofenphos (0.25 g AI/m^2). The recommended dosage for methoxychlor is 8-23 x higher than for other registered materials and 333 x higher than for permethrin. At the same dosage, 0.25 g AI/m^2, permethrin provided at least 80% mortality for 19 days while none of the other compounds were effective longer than 6 days. Four permethrin formulations (25% WP, 0.25% oil, 1.25% EC and 25% EC) were all similar in efficacy, quickness and residual activity at 0.00625 g AI/m^2.

As in 1979, permethrin at 0.007 g AI/m^2 provided 50-94% reduction in mosquito populations in 2 backyard trials. In 2 trials each at 0.25 g AI/m^2, malathion provided reductions of only 0-39% while declines of 0-79% were observed with iodofenphos.

Oviposition Sites for Monitoring *Culex* spp. Populations.

As in 1979, children's wading pools were again set up in the Guelph area to evaluate their use for monitoring *Culex* spp. populations. During the season, a mean of 522±162 (SE) egg rafts were collected from 5 pools with a mean weekly relative variation of 19.3%. The combined seasonal pattern in egg raft numbers from these pools was very similar to the pattern in numbers of *Culex* spp. females collected in 2 New Jersey light traps. Fewer females ($\bar{x}$ = 161) were collected in these light traps than egg rafts ($\bar{x}$ = 281) in 2 adjacent pools. The light traps showed a 74.6% population decline in 1980 compared to 1979 while the 2 pools indicated a similar 71.2% decline. The differences in seasonal patterns between the 2 years were also comparable in the pools and light traps.

In 1980, the seasonal patterns between pools were basically similar except that egg raft numbers in 3 pools were 88% lower than in the other 2 during a 3-wk period from 23 July to 12 August. Moderate to large populations of seed shrimps (Crustacea: Ostracoda) possibly *Eucypris rava* were present in these 3 pools. After they were treated with chlorpyrifos on 11 August, ostracod populations were greatly reduced and a concurrent 10-fold increase in egg rafts occurred the week following treatment. Egg raft numbers were generally similar in all pools thereafter.

To determine if the attractiveness of sod-lined oviposition sites changes during the season, weekly egg raft numbers were compared in galvanized metal tubs containing (A) the same sod and water all season, (B) sod flooded with fresh water each week, and (C) sod flooded 1 week previously, set up in a latin square design. The sod was from one batch purchased at the beginning of the season. Species composition was similar in the different tubs. No differences in attractiveness were noted during the first 9 weeks (mean weekly numbers: 22 in A, 20 in B and 21 in C). However, significantly fewer rafts were collected in A than B (6.5 vs 23.5, $p<.05$) during the next 3 weeks and intermediate numbers (14.4) were collected in C. When the sod but not the water was changed in 2 of the 3 A tubs, numbers increased to 36 the following week compared to 28 in the B tubs. Consequently, after 9 weeks the attractiveness of continuously flooded sod deteriorated greatly and was beginning to deteriorate in sod flooded for 1 week indicating that it should be replaced after 2 months, probably with freshly-cut material.

As in 1979, these results demonstrate that oviposition sites can be an accurate, simple and selective method for monitoring *Culex* spp. populations. To ensure constant efficiency the sod should be replaced at least once a season and seed shrimp populations prevented or kept under control.

Evaluation of Compounds for the Control of Immature Mosquitoes

Cypermethrin

In 1979, cypermethrin was the most promising pyrethroid tested for mosquito larval and pupal control in terms of its efficacy and safety to fish and other nontarget invertebrates. In 1980, cypermethrin again exhibited at least a 2-fold absolute safety margin to stickleback fish in simulated pools at cool temperatures using *Ae. stimulans* 4th instar larvae and pupae. *Culex* spp. at warm temperatures were used the previous year. In 2 natural snowmelt pools cypermethrin at 20 g AI/ha provided good control (90-100%) of larvae and pupae with no appreciable mortality to caged stickleback fish. Moderate to large reductions of most nontarget insect and crustacean populations occurred after these treatments.

Although preliminary tests indicated that *Ae. stimulans* larvae were less susceptible than *Culex* spp. larvae (24 hr LC50: 0.415 ppb vs 0.068 ppb) and *Ae. stimulans* pupae were also less susceptible than *Ae. vexans* pupae (72 hr LC50: 0.644 ppb vs 0.07 ppb), lower dosages are required to control *Ae. stimulans* (5-10 g AI/ha) than either *Culex* spp. or *Ae. vexans* (25 g AI/ha) in simulated pools, probably because of the negative temperature coefficient exhibited by cypermethrin. At 5 g AI/ha in simulated pools technical cypermethrin in Flit Mosquito Larviciding Oil(R) provided 100% mortality of *Culex* spp. pupae as did technical material in acetone whereas only 73% was achieved with the EC formulation. Finally, technical cypermethrin in acetone did not improve the safety margin to fish compared to the EC formulation. A better safety margin was expected on the basis of previous fish and mosquito laboratory bioassays.

Bacillus thuringiensis var. *israelensis*

In simulated pools one WP formulation (ABG-6108D) of *B. thuringiensis* var. *israelensis* provided 95% control of 4th instar *Culex* spp. larvae at 300 g/ha. Another formulation ABG-6108B gave such control only at 2.5 kg/ha. Susceptibility tests with 3rd instar *Culex* spp. larvae demonstrated that formulation D (48 hr LC50 = 0.0615 ppm) was ca. 15 x more toxic than B (48 hr LC50 = 0.943 ppm). The less effective formulation provided control of 3rd instar *Ae. stimulans* larvae only at 10 kg/ha. In simulated pool trials providing 93% mortality of *Culex* spp. larvae, little or no effect on nontarget Ostracoda (26%), Cladocera (7%) or Dytiscidae larvae (17%) was observed except, as expected, with Chironomidae larvae (89%).

Aedes stimulans larvae (48 hr LC50 = 0.167 ppm) were ca. 5 x more susceptible than *Culex* spp. (48 hr LC50 = 0.943 ppm) using formulation B. First instar *Culex* spp. larvae (48 hr LC50 = 0.0273 ppm) were ca. 5 x more susceptible than fourths (48 hr LC50 - 0.145 ppm) using formulation D. The susceptibility of 2nd instar *Ae. vexans* larvae was comparable (48 hr LC50 = 0.0253 ppm). *Bti* also was ca. 2 x more effective at 25° than 15°C in susceptibility tests using a 1979 WP feasibility formulation. This bacterium is a very promising, selective, biological insecticide for mosquito control in Ontario.

Bay SIR 8514

In 1979, WP and EC formulations of Bay SIR 8514 provided complete control of *Ae. stimulans* larvae at 10 g AI/ha in simulated pools. This is probably the minimum effective dosage in such pools as only 90% mortality was achieved at 8 g AI/ha 18 days after treatment with a 0.5% granular formulation in 1980 trials. In a natural snowmelt pool, ca. 80-90% control of 3rd instar *Ae. stimulans* larvae was obtained with the granular formulation at 15 g AI/ha. Similar reductions

were evident in a second pool before it dried up. A slightly higher dosage will probably provide excellent control in such pools. In the laboratory, 3rd instar Aedes spp. larvae were ca. 8 x more susceptible than Culex spp. larvae (LC50: 0.498 vs 3.81 ppb), probably explaining the 5-fold higher dosages required to control Culex spp. larvae in previous simulated pool trials. First instar Culex spp. larvae were 2-3 x more susceptible than 4th instar larvae (LC50: 3.38 vs 7.8 ppb).

Culex spp. Control Using Pest Management Strategies

Generation times and developmental periods for Culex spp. populations were monitored in a Guelph subdivision where catch basins were the major breeding site, in an effort to time insecticide applications precisely so that control of the critical populations, i.e. the first 2 generations, could be achieved effectively with minimum labour and insecticide use. Oviposition sites were used to assess generation times, population levels and efficacy of the program while caged larvae and regular sampling of natural larval populations were used to monitor developmental periods.

The oviposition sites were set out 21 May. The first egg raft was collected 26 May and required ca. 17-18 days for development to 4th instar larvae. At this time, natural pupae were present in catch basins indicating that some egg rafts were laid before the oviposition sites were set out. However, only small populations were detected in 4 of 27 driveway basins and none in street basins. These 4 were treated on 11 June with 1 ml Flit MLO/basin to control both larvae and pupae. Complete control was achieved but by 18 June, 7 days after treatment, caged larvae were again surviving in these basins. Subsequent reductions in egg raft numbers of ca. 20% were observed between 18 June and 8 July in the subdivision.

Oviposition commencing the second generation began about the 16-23 June. Eggs laid 14-15 June required 10-11 days to develop to fourth instar larvae. At this time, natural populations consisted of all larval instars but no pupae. Most driveway basins containing water had larvae while none were found in street basins. All driveway basins with water were treated with 3.9 ml Altosid SR10/ basin on 30 June. Following this, egg production in the subdivision was reduced ca. 50% between the 9 and 22 July. On 10 July, 2nd-4th instar Culex spp. larvae were found in some of the street basins. Consequently all 156 street basins were treated with Altosid SR10 on 11 July. Subsequent reductions in egg raft numbers of ca. 70% were noted from 23 July to 2 September. The Altosid treatments provided 93-99% inhibition of adult emergence for 8 wks and 89% for at least another 2 wks when evaluation was terminated. On the basis of these results, one Altosid treatment of all basins when first generation larvae have reached 4th instar should effectively control the critical populations breeding in this subdivion.

Developmental Rates of Spring Aedes spp. Mosquitoes in Relation to Plant Phenology (R. Westwood)

Control of spring Aedes larval mosquitoes in southern Ontario has proven ineffective at times because insecticide applications were made either too early or more likely too late for effective results. A method of forecasting mosquito development and emergence utilizing the phenological stages of selected plant species as indicators is proposed. The phenological data will be developed to provide municipal control personnel with a simple inexpensive procedure to determine when mosquitoes are hatching (e.g. crocus budding), when treatment should be applied (e.g. daffodils in bloom) and when adult emergence

has occurred (e.g. wild cherry in bloom). The major assumption behind this method is that plant development is dependent on the range and degree of weather conditions which affect insects.

The study is divided into two areas. The first will be an attempt to correlate the development of certain spring *Aedes* mosquito species with the phenology of various plants. The second area of study will encompass a determination of the developmental rates of these spring *Aedes* species in the field and in the laboratory at different temperatures.

Sampling of spring *Aedes* larvae was carried out in three different breeding habitats (a cedar bog, deciduous woodland pool and an open field pool). Each pool was sampled once every three days using cylinder, minnow trap and bucket type samplers. Sampling commenced 20 March and continued on a daily basis until 29 May. Approximately 600 samples (with 10-75 larvae each) from 22 April through 29 May have been analysed to date. Mosquito species found include *Aedes provocans*, *Ae. stimulans*, *Ae. euedes*, *Ae. cinereus*, *Ae. excrucians*, *Ae. fitchii*, *Ae. canadensis* and *Culiseta morsitans*. During this period the dates of first bud break, first leaf and full leaf were recorded for 96 shrub and tree species for eventual correlation with larval development.

From 1 June through 20 August over 500 adult females of the previously mentioned species were collected, blood fed and induced to lay eggs for determination of developmental rates in the laboratory. Approximately 20,000 eggs have been collected for this purpose.

Effectiveness of the Mosquito Control Program in Essex Co. 1976-1978

Comparison of mosquito numbers collected in Essex Co. during 1980 when no control program was performed with the numbers captured during 1976-1978 when there was a program strongly suggests that the program was effective in substantially reducing mosquito populations. Four to 13-fold larger populations were present in 1980 and numbers of *Culex* spp., the primary target of the program, were 7-19 times higher. No such increase in *Culex* spp. populations was observed in Guelph. The proportion of *Culex* spp. in the total catch during 1976-1978 was also lower (31-38%) than in 1980 (51%). As expected, the smallest increases were observed for those species which should have been controlled least efficiently by the methods used, e.g. *Mansonia perturbans* and spring *Aedes* spp.

Population Dynamics of *Culex pipiens* and *Culex restuans* in Southern Ontario (D. J. Madder)

The population dynamics of *Culex pipiens* and *Culex restuans*, the probable vectors of St. Louis Encephalitis (SLE) in southern Ontario, were monitored using oviposition traps during 1978, 1979 and 1980. *Culex pipiens* had three to four generations with first oviposition 9 to 19 May and last, 28 to 30 September. Each year the oviposition activity of *C. pipiens* increased to a maximum in the third generation during late July and then declined. *Culex restuans* had two to three generations with first oviposition 6 to 19 May and last, 28 September to 15 October. In 1978 and 1979, maximum oviposition activity by this species was in late June and early July during the second generation, although in 1980 maximum activity was in July during the third generation. Important factors influencing the number of generations each year and their relative size are induction of diapause and larval competition. By early August of 1979 and 1980 field and laboratory studies showed that >90% of the

C. pipiens eggs laid would produce adult females in diapause, whereas C. restuans would reach the same incidence of diapause by mid-July. This difference is the primary reason for the extra generation of C. pipiens and is probably due to the poor success of C. restuans larvae under high competition pressure. At high larval densities C. restuans has significantly lower survival rates and longer developmental times than C. pipiens.

For both species the most important generations to control to prevent an outbreak of SLE are the first two, developing from early May to late July. Control after July is not efficient due to the very high (>90%) incidence of diapause in both populations. Diapausing females rarely take blood and therefore cannot carry the disease. The single most important generation is the second of C. pipiens, as temporal and epidemiological factors suggest it as the most important in carrying SLE virus to man.

20. Tomlin, A. D., and Tolman, J. H. - Feasibility of using parasites and/or predators in a program of integrated control of the onion maggot.

Rearing onion maggots (Hylemya antiqua Meigen) at high density at the Fanshawe Experimental Farm in London from 1978 to 1980 has allowed us to isolate and identify 4 parasites and 33 predators of this pest. The parasites were Aleochora bilineata, Oxypoda sp. (staphylinid beetles), and Aphaereta pallipes and Trichopria sp. (parasitic wasps). The predators fell into several different taxonomic groups; the most numerous were beetles (Coleoptera) - 23 species, and mites (Acari) - 5 species. Predatory species were also found in the Diptera (flies), Myriapoda (centipedes), Hymenoptera (ants), and Hemiptera (true bugs). Laboratory feeding studies were carried out with field-collected specimens to determine which stages of the onion maggot were attacked.

During 1980, 22 of the parasitoids (parasites + predators) originally observed at the London field station were also observed at experimental sites established at 3 major onion-growing marshes in Ontario (Thedford, Holland, Keswick). In all cases, comparisons of parasitoid frequency and occurrence between hedgerow and seedbed revealed significantly higher parasitoid activity in the hedgerow. With one exception there was much less parasitoid activity at the marshes than at London. A. pallipes was very common at the London field station, but virtually absent from all the seedbed sites at the marshes. However, the hedgerows at Thedford sequestered substantial populations of A. pallipes.

The culture of A. pallipes was originally recovered from H. antiqua pupae collected at the Fanshawe Experimental Farm and brought into the laboratory. Adults were housed in plastic cylindrical cages 40 cm long x 33 cm diameter and fed water and raisins. Third instar onion maggots presented to the adult parasites produced good egg laying response in the parasite. However, this technique was cumbersome and required manipulation of the parasites which presented difficulties. A technique which decreased labour requirements by 50% was devised using 35 x 20 x 10 cm plastic tubs set with 1000 H. antiqua eggs and cut onions. Onion maggots developed for 7 days at 25°C at which time 400 new eclosed parasites were added to the tub which was sealed with a tight fitting ventilated lid. Onion maggot pupae were washed out of the tubs 10 days after infestation. Approximately 7 days later about 6000 parasites per tub emerged from the onion maggot puparia (a parasite infestation rate of ca. 90%).

Experiments are underway to develop a culture of parasites capable of entering diapause. These can be stored for field experiments.

Screening results of direct contact toxicity of 21 insecticides to A. pallipes ranged from highly toxic (e.g. parathion), moderately toxic (e.g. permethrin), to nontoxic (e.g. diflubenzuron). Several candidate insecticides plus insecticides currently used for onion maggot control were tested to determine the LD_{50} for A. pallipes. Parathion, for example, was 11.7 x more toxic to A. pallipes than permethrin. In addition, the direct contact activity of 5 insecticides to A. pallipes adults was compared to that of H. antiqua. Parathion was 11.7 x as toxic to A. pallipes as to H. antiqua, but permethrin was slightly less toxic to A. pallipes than to H. antiqua.

Results of screening tests in moist muck soil ranged from highly toxic causing mortality of adult A. pallipes at less than 1 ppm (e.g. terbufos) to virtually non toxic causing no mortality at 100 ppm (e.g. chlorfenvinphos). The LD_{50}'s for 6 insecticides incorporated into moist muck soil were determined, and the toxicities compared to chlorfenvinphos.

Since the concentration of insecticides used in seed furrow treatments at recommended application rates is ca. 100 ppm, many insecticides would cause mortality of foraging A. pallipes. We conclude that an integrated control program for the onion maggot involving the use of A. pallipes as a control agent, would require the use of insecticides which have low toxicities to A. pallipes in order to ensure its continued effectiveness.

Results from sublethal toxicity tests with parathion and diazinon against A. pallipes adults suggest a slight reduction in both fecundity and/or fertility of the parasite.

In September approximately 50,000 A. pallipes were released at each of two locations on the Thedford Marsh. Control and release blocks of 500 m^2 were established at each location. At the Pachlarz farm parasitized pupae were buried in dispersal pots, A. pallipes thus emerging in the field; adult A. pallipes, after emerging and feeding in the lab were released at the Donald farm. At each site individual A. pallipes adults were recaptured in yellow sticky traps as far as 45 m from the release centre; most were recaptured within 10 m. Rate of parasitism will be determined in a) pupae extracted from "micromountains" (ca. 0.25 m^2 onion maggot mass rearing beds), b) pupae extracted from pots of seedling onions placed in the field and c) pupae collected from the field (the "wild" population). Field conditions in September generally induce pupal diapause in H. antiqua; however, by removing maggots from a) and b) to the laboratory it was possible to obtain preliminary results. Where A. pallipes emerged in the field, the rate of parasitism in pupae collected as in a) was 13.3% in the release block and 0.5% in the control block. Adult H. antiqua emergence was reduced 20.9% in the release block. Release of adult Aphaereta at the other site was not as successful. Pupae collected by method b) showed a similar pattern, but the rate of parasitism reached a maximum of only 7.0% at the Pachlarz farm. Pupae collected by all three methods are currently being chilled to break diapause; rates of parasitism for these pupae will be determined in January.

21. Wukasch, R. T. - Effect of companion planting on pests in the home garden.

Research continued for a second growing season to assess non-chemical methods of pest control for the home gardener. Methods of companion planting, the interplanting of crops with various plants, were again tested for controlling pests of cabbage, potatoes, and roses. Cattle manure, blood and bone meals were used as fertilizers, while mulches and cultivation were used for weed control. No pesticides were used except those applied to sprayed plots in each experiment.

Companion plants, including herbs such as wormwood, (Artemisia absinthium) chives (Allium schoenoprasum), garlic (Allium sativum), horseradish (Armoracia rusticana), peppermint (Mentha piperita), thyme (Thymus vulgaris), sage (Salvia officinalis), basil (Ociumum basilicum), hyssop (Hyssopus officinalis), parsley (Petroselinum crispum), catnip (Nepeta cataria), tansy (Tanacetum vulgare); crops such as flax, snapbean, tomato and celery; and ornamentals such as marigold (Tagetes patula), nasturtium (Tropaeolum majus), and geranium (Pelargonium hortorum), were planted surrounding and within plots of potatoes, cabbage or roses. Unsprayed check and sprayed plots were also included in each experiment, replicated four times. Pest and disease levels were evaluated biweekly by visual and sweep net samples. Crop yield and quality data were also obtained.

Twenty-five Colorado potato beetles (CPB) were released around the perimeter of each potato plot on June 12, 1980. Only in the sprayed plots was excellent control of the CPB and potato leafhopper (PLH) obtained; however, bean, marigold and nasturtium plots had fewer than half the number of adult CPB than in the check plot. Furthermore, bean, flax and horseradish had significantly fewer PLH adults than did the check. However, these apparent controls did not translate into injury reduction or yield increases. Only the sprayed plot had significantly less injury and 26% greater yield than the unsprayed check. Horseradish significantly reduced yield by 30%. No treatments significantly affected numbers of potato flea beetles, while aphids were an insignificant pest in 1980.

As in 1979, cabbage pests such as the imported cabbageworm, diamondback moth, and the crucifer flea beetle, again were mostly unaffected by companion plants. Significant control of all three pests was only observed in the sprayed plots. The number of cabbage loopers, aphids, cutworms, and cabbage maggots were again too small to warrant comparisons. Though sprayed cabbages had the highest quality and weight, the total yield did not significantly differ from the check. However, marketable yield was increased by 50%. Most other companion treatments did not differ from the check, except that the competitive effects of tansy, tomato, wormwood, and catnip significantly reduced cabbage yield. Slugs were prevalent in the cabbage plots and confounded ratings of foliar injury.

Results from the rose experiment were not significant in 1980. A large number of roses were winter-killed, and many of those replaced by new rootstocks in May were not very vigorous.

As in 1979, few results substantiate popular claims that companion plants repel insects and disease organisms. Despite reductions in pests in some companion-crop associations, these reductions were usually not below the economic threshold. Competition between vigorous companion plants may severely reduce yield. Though acceptable yields of cabbage and potatoes were realized without pesticides, the quality was substantially poorer than that in sprayed plots.

22. Research proposals funded in 1979-80 and completed in 1980-81.

Brown, R. H., Ingratta, R. G., Konecny, J. D., and Lucke, J. D. Comparison of wipe-on and wick applicators for glyphosate application to control escaped weeks in crops.

Applying herbicides to weeds growing above a crop is another dimension in the control of weeds. Development of wick-applicators, and roll-on appli-

cators has provided a means of applying herbicides to weeds without significant crop injury and without loss of herbicide to non-target areas. Because the rate of speed of travel, the kind of equipment used, the kind and concentration of herbicide and the weed-crop situation influence the degree of control and crop safety, this study was conducted to compare a pipe wick (two rows of cotton wicks), a Bobar wick (nylon multi-rope) and a roller (nylon rug) applicator. Glyphosate was used at various concentrations with the roller applicator (2.5, 5.0 and 10%) and at 33 1/3% with both wick applicators. Rate of speed of travel was varied (2.5, 5 and 7.5 mph or 4, 8, and 12 km/h) for each treatment and each treatment was applied once or twice (travelling in opposite directions). Each treatment was replicated only once in each field situation. An area 3 meters wide and 100 meters long was treated in each case. A field of soybeans infested with milkweed and a field of alfalfa infested with velvetleaf, redroot pigweed, ragweed, green foxtail, yellow nutsedge and barnyard grass were used as the main test sites. Other weed-crop sites included soybeans (Canada thistle), soybeans (hemp dogbane, milkweed), pickling cucumber and soybeans (milkweed, hemp dogbane), alfalfa, red clover, forage grasses (milkweed), whitebeans (milkweed, volunteer corn) and kidney beans (velvetleaf, pigweed, ragweed, lamb's quarters).

Milkweed, hemp dogbane and volunteer corn were usually controlled at the 90 to 100% level if contacted by glyphosate at or near bud to flower stage for milkweed and hemp dogbane and at 1 m ht of corn. Annual weeds such as velvetleaf, pigweed, ragweed and foxtail were not controlled as readily. The 4 km/hr speed is too slow and did not control weeds to any better degree than the 8 km/hr speed. The 12 km/hr speed was too fast resulting in less effective control and more splattering of glyphosate onto crop plants adjacent to weeds. Velvetleaf is one of the more difficult annual weeds to kill. The 2½% solution of glyphosate in water was not concentrated enough. The 5% solution was adequate for the roller applicator with the less difficult weeds but the 10% solution was preferable when the more-difficult-to-control weeds were encountered. One pass over the field was adequate when weeds such as milkweed, hemp dogbane or volunteer corn were to be controlled. When annual weeds, particularly velvetleaf was encountered, 2 passes over the field were more effective than one.

The pipe wick applicator provided slightly better or equivalent control of weeds compared with the Bobar applicator. Both wick applicators were equivalent or mostly superior in performance compared with the roller applicator. Perhaps the materials, namely cotton versus nylon influenced these results because they delivered different rates of glyphosate.

Crop injury was minimal except where weeds that had glyphosate applied to them touched the crop plant. Crop yields were not taken.

The new dimension in weed control has many possibilities particularly for controlling perennial weed escapes in shorter row crops. Many facets of this rescue operation, however, are not adequately researched at the present time. Glyphosate is not yet registered for use for rubbing or wiping-on to weeds in a specific crop using a wick or roller-applicator.

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APPENDIX IV. Publications and theses relating to Ontario Pesticides Advisory Committee Research Programs, April 1, 1980 - March 31, 1981

Allan, S. A.; G. A. Surgeoner; B. V. Helson and D. H. Pengelly. 1981 Seasonal activity of Mansonia perturbans adults (Diptera: Culicidae) in southwestern Ontario, Can., Ent. 113: 133-139.

Broadbent, A. B. 1980. Assessment of a litterbag technique for studing the decomposition of leaf litter and the effects of carbofuran on non-target soil invertebrates. Ph.D. thesis presented to the Faculty of Graduate Studies, University of Guelph.

Chapman, R. A.; C. M. Tu; C. R. Harris and C. Culp. 1981 - Persistence of five pyrethroid insecticides in sterile and natural, mineral and organic soil. Bull. Environm. Contam. Toxicol. 26: 513-519.

Husby, W. D. 1980. Biological studies on the eastern subterranean termite Reticulitermes flavipes (Kollar) in southern Ontario. Master thesis presented to the Faculty of Graduate Studies, University of Guelph.

Hughes, D. N.; M. G. Boyer; M. H. Papst and C. D. Fowle. 1980. Persistence of three organophosphorus insecticides in artifical ponds and some biological implications. Arch. Environm. Contam. Toxicol 9: 267-279.

Madder, D. J. 1981. Biological studies on Culex pipiens L. and Culex restuans Theo., in southern Ontario. Ph.D. thesis presented to the Faculty of Graduate studies, University of Guelph.

Mason, W. M. A. 1981. The effect of varying spray volume and droplet size on the activity of several pre-plant incorporated herbicides applied with a controlled droplet applicator. Master thesis presented to the Faculty of Graduate Studies. University of Guelph.